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Cover: Ornate false spider mites (Tuckerellidae) are early derivative members of the economically important Tetranychoidae - spider mites, clover mites, flat mites, etc.. This species, *Tuckerella* sp. nr. *flabellifer* Miller, feeds on the stems of the introduced weed lantana and on a variety of native trees and shrubs. Illustration by Juanita Choo, Department of Zoology and Entomology, University of Queensland.

LARVAL DEVELOPMENT IN *HETERONYMPHA MEROPE MEROPE* (FABRICIUS) (LEPIDOPTERA: NYMPHALIDAE)

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Abstract

In New South Wales, newly hatched larvae of *Heteronympha merope merope* (Fabricius) in autumn are bimodal with respect to feeding behaviour. Non-feeding larvae failed to survive or commence feeding when held in warm (28°C) temperatures and long (15 h) photoperiod (P). Feeding larvae developed rapidly in these conditions to the final instar but were unable to pupate. Post-hatching exposure (1-3 months) of feeding larvae to autumn-winter conditions of cool temperatures and declining photoperiod, prior to transfer to 25°C, 15 h P, enabled development through to adulthood. Larval development in *H. merope* is discussed with respect to the apparent existence of diapause and host grass availability.

Introduction

Heteronympha merope merope (Fabricius), the common brown butterfly, is widespread in southeastern Australia, occurring in a wide range of habitats from metropolitan gardens to mountain forests (Common and Waterhouse 1981). In New South Wales adults first appear in October-November with males exhibiting marked protandry (Edwards 1973). Edwards (1973) suggested that females aestivate and showed that although mating occurred soon after emergence in spring, ovarian development did not occur until autumn, when eggs are laid on soft grass host plants. James (1988) presented additional data confirming aestivation and summer reproductive dormancy in *H. merope*. Females were unable to develop reproductively, regardless of temperature and daylength, until early January, suggesting the existence of an obligatory reproductive diapause. After a period of exposure to summer-like conditions egg production is stimulated by cool temperatures and shortening photoperiods (James 1988).

Oviposition by *H. merope* generally occurs during March-April (Edwards 1973, Fisher 1978), although James (1988) showed that females were gravid as early as mid February in the lower Blue Mountains. Fisher (1978) reported that eggs laid in April hatched after about 12 days. The larvae feed actively but are still 'early instars' in June and July (Fisher 1978).

This paper provides information on the dynamics of larval development and an apparent second diapause in the life cycle of *H. merope*.

Materials and Methods

Initial observations (1984)

Ten to 15 female *H. merope* collected in early March at Hazelbrook in the Blue Mountains, west of Sydney, were allowed to oviposit on potted kikuyu and other soft grasses in a constant growth cabinet (CGC) set at 25°C with a 10 hour photoperiod. The butterflies were confined in a steel-framed, muslin covered cage and fed a 10% sugar/water solution. Eggs were collected,

placed on moistened filter paper in glass petri dishes and held at 28°C under a 10 hour photoperiod. Upon hatching (20 March-6 April), ~100 larvae were transferred with a fine brush to potted grass and held in a temperature controlled glasshouse (range 22-30°C) under naturally declining photophase (12-10 h).

Laboratory studies (1985)

Fifteen to 20 females collected in early April at Hazelbrook were allowed to oviposit during 9-21 April on potted grass in a temperature controlled (range 22-30°C) glasshouse under naturally declining photophase (~10 h). The butterflies were confined in a wooden framed, muslin covered cage and fed a 10% sugar/water solution. Eggs began hatching on 20 April and most of the potted grass and eggs were transferred to a constant temperature room (CTR) (28±1°C/15 h photophase (P)) (summer-like conditions) on 24 April. A small number of eggs (~50) in a single pot of grass were kept outdoors at Hazelbrook from 24 April until 16 August, when larvae were transferred to summer-like conditions until adult emergence. The major group of feeding larvae (~120) was maintained and monitored under the summer-like conditions until 5 July, when remaining individuals (~60) were split equally between (1) a CTR at 28°C/15 h P, (2) a glasshouse at 20-25°C and natural daylength (~10 h) and (3) a CGC at 16-18°C/7 h P. The few larvae remaining at the end of July were combined into a single colony on potted grass and held under ambient laboratory conditions (15-23°C/natural P).

Laboratory studies (1998)

Twenty-four females were collected on 29 March from open woodland adjacent to the Murrumbidgee River at Yanco in southern New South Wales. The following day they were placed with potted kikuyu in a steel-framed, muslin covered cage in a CTR set at 27.5°C/15 h P and fed a 10% sugar/water solution. Three experiments were conducted to determine whether larvae undergo diapause as judged by the duration and success of development under summer-like conditions, preceded or not by varying exposure to ambient autumn/winter temperature/photoperiod.

On 6 April, approximately 40 newly laid eggs were removed from the oviposition cage, placed on moistened filter paper in a glass petri dish and incubated at 5°C (CTR) for four weeks, before transfer to 25°C/15 h P (CTR). Similarly, a group of larvae (n~25) which refused to feed since emergence 14 days earlier, were incubated at 5°C for two weeks before transfer to 20°C/15 h P. Mortality and development of larvae were recorded for both groups.

Two pots of kikuyu grass which recruited approximately 100 eggs each during exposure to female *H. merope* over two days (30-31 March), were held outdoors in wooden/muslin cages under ambient temperature and photoperiod from 1 April to 20 July. Groups of larvae (14-25 individuals)

were collected from the cages on 14 April (~4 days after hatching), 18 May, 15 June and 20 July. They were held in plastic/muslin rearing containers with potted grass in a CTR set at $25\pm 1^\circ\text{C}/15\text{ h P}$. Larvae sampled on 14 April contained feeding and non-feeding individuals whilst subsequent samples contained feeding larvae only. Mortality and development of larvae in the summer-like conditions were recorded.

Results

Initial observations (1984)

Females laid eggs readily, attaching them to grass blades and stalks as well as cage sides and on a few Compositae plants mixed in with the grass. Eggs took 8-9 days to hatch and by 6 April most had hatched. Newly hatched larvae were around 1.5 mm long and creamy white in colour. A distinct bimodalism in feeding behaviour was observed, with ~30% of larvae feeding within hours of emergence and becoming green in colour. The remainder became immobile taking up positions close to the hatched egg and not feeding. These larvae remained creamy-white in colour and died after 2 to 4 weeks. By 15 May, most feeding larvae were in late first or early second instar, 1-1.5 cm long and green. Mortality of larvae increased rapidly during June and the colony died out by early July.

Laboratory Studies (1985)

Newly emerged larvae again showed feeding or non-feeding behaviour. All non-feeding larvae died within 2-3 weeks. The feeding larvae showed good early development under summer-like conditions, with rapid growth and little mortality during the first 4-5 weeks. During weeks 4-9, development slowed and more than 50% of larvae died from moulting difficulties and disease. Survivors reached their final instar by the end of June (9 weeks). All larvae retained in the 28°C environment died by the third week of July. High mortality continued amongst the final instar larvae transferred to the two milder environments and no pupation occurred. Twenty-two survivors subsequently transferred to laboratory conditions died by early September without pupating.

Twelve second and third instar larvae from the outdoor colony transferred to summer-like conditions in mid-August, showed rapid growth and no mortality, reaching the final instar within two weeks. All larvae pupated in early September and emerged as adults at the end of the month.

Laboratory studies (1998)

Newly laid eggs, incubated at 5°C for four weeks, appeared to show embryonic development (internal darkening), but failed to hatch when subsequently held at $25^\circ\text{C}/15\text{ h P}$. Non-feeding first instar larvae, held at 5°C for two weeks, failed to feed and died within a week when subsequently exposed to $20^\circ\text{C}/15\text{ h P}$. A single individual commenced feeding but died after two weeks.

A sample of 50 larvae (four days old) held at 25°C/15 h P, yielded 36 (72%) non-feeders and 14 (28%) feeders after 14 days. All of the non-feeders died within three weeks. After four weeks only four feeders remained alive and these died after eight weeks, after reaching the final instar (Table 1). Outdoor larvae (second instars), transferred to 25°C/15 h P after one month (18 May) developed fairly slowly and only 54% reached third instar after about six weeks (Table 1). The first pupae were formed after nine weeks with 32% of larvae reaching this stage. The first adult emerged after 13 weeks and the last after 16 weeks, with 22% of larvae reaching adulthood (Table 1). Larvae transferred to 25°C/15 h P after two months outdoors (second instars) developed faster and had improved survivorship with 45% pupating after 7-10 weeks. A total of 27% reached adulthood after 10-12 weeks (Table 1). Outdoor larvae on 20 July (three months since hatching) were still in the second instar and showed similar development and survival rates to larvae transferred after two months (Table 1).

Table 1. Development of *Heteronympha merope* at 25°C/15 h P following transfer of larvae hatched 10-14 April from outdoor conditions at Yanco, NSW during April-June 1998.

Post-hatch period outdoors	% larval mortality	% pupation (n)	% eclosed adults (n)	Mean (\pm SE) larval duration (d)
NIL	100 (21)	0	0	-
14.iv - 18.v (34d)	68 (17)	32 (8)	22 (5)	101.6 \pm 4
14.iv - 15.vi (62d)	54 (12)	45 (10)	27 (6)	76.7 \pm 3
14.iv - 20.vii (88d)	43 (6)	57 (8)	36 (5)	72.2 \pm 3

Discussion

H. merope larvae in southern Australia develop very slowly during autumn and winter, taking 6-7 months to reach pupation (Common and Waterhouse 1981, Fisher 1978). This study suggests that the development of larvae is regulated by diapause.

First instar larvae occur in two behavioural forms, feeders and non-feeders. The fate of non-feeding first instars is unknown and should be investigated (do they die or do they gain feeding competency later in autumn/winter?). The fact that non-feeding larvae in this study did not survive exposure to, or begin feeding under summer-like conditions, suggests that they are in diapause (see below).

Larvae of *H. merope* that feed upon hatching take advantage of the normally favourable temperature conditions and usually abundant host grass resources in April-May, and develop to second instars by early winter (Fisher 1978 and this study). However, second instar larvae in mid-autumn, compared to the

same stage larvae in late autumn-late winter, differ in their competency to complete development under summer-like conditions. Second instar larvae in mid-autumn, exposed to long days and warm temperatures, are unable to pupate, whilst larvae collected during late May-late August pupate successfully under summer-like conditions. Thus, mid-autumn larvae appear to be refractive with respect to full development. A refractory, conditioning or restoration period (defined as a temporary inability to develop under normally favourable environmental stimuli) is a key characteristic of diapause (Danks 1987). If the prolonged larval period/dormancy in *H. merope* was simply quiescence caused by the direct effect of cool temperatures and short daylengths, inhibition of development under favourable conditions would not occur at any time. Similarly, the inability of non-feeding first instar larvae to survive, feed or develop under summer-like conditions, is also indicative of diapause.

Feeding larvae gained competency to complete development after exposure for only one month (14 April-18 May) to ambient conditions. Temperatures were relatively high (mean daily maximum = 21°C, range 15-27°C) at this time suggesting that declining daylength, rather than temperature, facilitated diapause development (Tauber and Tauber 1976). The apparent diapause in *H. merope* larvae does not appear to be instar-specific. Diapause was clearly broken in second and third instar larvae that showed rapid development under summer-like conditions, after collection from outdoors in August 1985. These larvae may have been first instar 'non-feeders' and perhaps completed diapause development in that instar. In contrast, larvae exposed to summer-like conditions from hatching, developed to the final instar before reaching an apparent physiological 'block' to development.

Autumn germination and development of soft grasses, particularly in inland areas of south eastern Australia, is critical to the development and survival of *H. merope* larvae. However, the arrival of autumn 'rains' is sometimes delayed and growth of grasses may not occur until late May/early June in some years. The apparently fixed occurrence of non-feeding first instar larvae of *H. merope*, may be an example of a 'bet-hedging' strategy to ensure that a significant portion of the population survives until host grasses become available. It would be interesting to compare the proportion of non-feeders to feeders in coastal and inland populations of *H. merope*.

A number of insects have been reported to have two or more dormant stages in their life cycle (Danks 1987 and references therein). Larval dormancy and adult aestivation has been recorded in some carabid beetles (Thiele 1969), sciomyzid flies (Berg *et al.* 1982), the lacewing *Nineta flava* (Canard 1982, 1983) and the moth *Triphaena pronuba* (Akhmedov 1977). Dormancies in two stages does not appear to have been reported previously from nymphalid butterflies.

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A NEW SUBSPECIES OF *BINDAHARA MEEKI* ROTHSCILD & JORDAN (LEPIDOPTERA: LYCAENIDAE) FROM NEW IRELAND, PAPUA NEW GUINEA

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Abstract

Bindahara meeki kolmaui ssp. nov. is described and illustrated from Central New Ireland, Bismarck Archipelago. Detailed morphological and structural comparisons are made with the nominotypical subspecies from mainland Papua and Irian Jaya. The immature stages of *B. m. kolmaui* are described and *Salacia* sp. nr *disepala* (Hippocrateaceae) is recorded as a foodplant.

Introduction

The genus *Bindahara* Moore was previously considered to contain three species, *B. phocides* (Fabricius), *B. meeki* (Rothschild & Jordan) and *B. arfaki* Bethune-Baker, until Parsons (1998) showed that the latter two taxa are conspecific, *B. meeki* having priority. Parsons (1998) recognised that only males were known of *B. meeki* and only females of *B. arfaki*, hence prior confusion can be attributed to the extreme sexual dimorphism.

Depositories are abbreviated as follows: ANIC – Australian National Insect Collection, CSIRO, Canberra; CJMC – Private collection of C. J. Müller.

***Bindahara meeki kolmaui* ssp. nov.**

(Figs 1-5, 7-9, 11)

Type material. Holotype ♂ (ANIC genitalia slide No. 13095), PAPUA NEW GUINEA: Schleinitz Mts., 1260 m, Central New Ireland, 24.vii.1998, C. J. Müller (in ANIC). Paratypes: 1 ♂, same data as holotype but 27.vii.1998 (CJMC); 1 ♀, same data as holotype but ex-ova, emerged 1.ix.1998, pupated 19.viii.1998 (ANIC); 1 ♀, same data as holotype but 24.vii.1998 (CJMC).

Description. Male (Figs 1, 2, 5). Forewing length 20 mm; antenna 12 mm. Head black with eye ringed white anteriorly; antenna black, ringed white, with club tipped orange-brown, nudum proximal to club ventrally grey-brown; labial palpus long, black dorsally, white beneath. Thorax black with fine brown hairs above, beneath grey; legs pale grey. Abdomen black, white ventrally. Forewing with costa bowed strongly near base, termen nearly straight; above black with a broad area, excluding cell and central median area, iridescent purple, visible only at certain acute angles, cilia black; beneath, ground colour dark grey-brown, pale brown from base to postmedian area beneath vein CuA₂, nine white bars of variable width running approximately normal to costa, termen and submarginal line tending orange towards dorsum, postmedian pair of lines becoming congruous at vein CuA₁, median pairs of lines intersecting at costa. Hindwing with long orange

tail at vein CuA_2 , termen stepped abruptly, distally between veins CuA_1 and CuA_2 , lobed at tornus; above black with bright orange tornal area from vein M_2 irregularly to median area of dorsum, paler progressively towards inner margin, lobe black with metallic blue centre, cilia black along apex and anterior one-third of termen, orange along remainder, large disc-shaped sex brand in basal area between cell and vein $Sc+R_1$; beneath, ground colour brown-black with a series of white bars orientated obliquely to costa, from base to termen, postmedian and marginal lines merging and becoming progressively orange towards tornus, median pale line very obscure, white median bars congruent at junction of cell and vein M_1 , bottom of cell and vein CuA_1 broadly orange, an irregular black bar oblique to dorsum from median to postmedian area, two black spots, uppermost oval in shape, proximally blue to white, lobe broadly black, metallic blue at tornus.

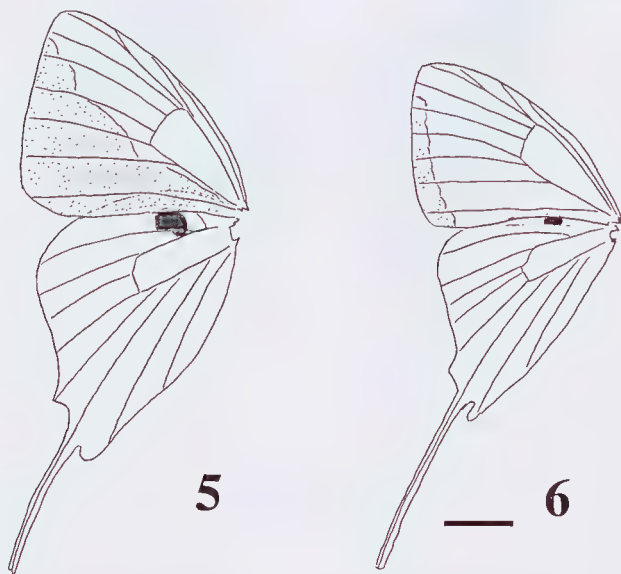
Genitalia (Fig. 11). Genitalic ring oval; sociuncus broad and U-shaped anteriorly; brachium long, apically slender, strongly dipping; valva long, slender, somewhat flattened laterally, median distal blunt processes laterally, enlarged and squared apically; phallus elongate, pointed apically, with dense setae subapically.

Female (Figs 3, 4). Forewing length 19 mm; antenna 10 mm. Head deep grey, white anteriorly and ventrally; antenna black dorsally, whitish-grey ventrally, club grey-brown; tipped orange-brown, labial palpus long, black, beneath basal two segments white. Thorax grey with flimsy hairs laterally, beneath whitish-grey; legs grey dorsally, white ventrally. Abdomen grey dorsally, white ventrally. Forewing with costa bowed near base and inner margin near tornus, termen fairly straight; above grey-black with broad white median area extending from lower distal portion of cell to inner margin and near base, boundary with ground colour gradational, basal area below cell with scattering of grey scales; beneath, ground colour white, with a series of black bars running normal to costa (broad bar in sub-basal area reaching to near dorsum, two narrower black bars in median to postmedian area and reaching to vein CuA_2 , two broad marginal and submarginal bars, meeting at tornus). Hindwing with apex rounded, termen straight to vein CuA_1 , stepped between vein CuA_1 and tornus and with long tail at vein CuA_2 , lobed conspicuously; above white with distal one-third black, basal area with scattered grey scales, vein $1A+2A$ heavily black, and to inner margin grey, narrow white line just proximal of termen and also in centre of tail which is otherwise black with faint traces of pale metallic blue, lobe black with metallic blue centre, cilia black; beneath white with distal one-quarter black, partially bisected by submarginal band of elongate bluish-white spots, a black bar, running obliquely to costa from base to bottom of cell, an irregular black bar from base to tornus, congruous with dorsum, a black bar, oblique to dorsum from near base to vein $1A+2A$, a narrow band of white subterminal spots, two elongated metallic blue tornal spots, two white spots proximal to these, postmedian area near tornus bright yellow, tail black with white centre, dorsum broadly black, cilia black.



Figs 1-4. Adults of *Bindahara meeki kolmaui* ssp. nov. Odd numbers upperside, even numbers underside. (1, 2) male; (3, 4) female.

Etymology. The new taxon is named in honour of Mr Gabriel Kolmau, Kandaunan Village, New Ireland, for his hospitality and friendship to one of us (CJM) during field research undertaken in this study.



Figs 5-6. Adult male uppersides of *Bindahara meeki* subspecies, showing extent of iridescent purple (stippled) and sex brand (filled). (5) *B. m. kolmaui*; (6) *B. m. meeki*.

Life history

Foodplant (Fig. 10). Fruit of *Salacia* sp. nr *disepala* (Hippocrateaceae).

Egg. Diameter 0.85 mm, wider than high, white with bluish tinge, strongly pitted with fine spines along pit peripheries.

Larva. Final instar (Fig. 7) 21 mm long, flattened laterally, especially anteriorly, distally flanged and indented between segments, with conspicuous setae, glossy blue-black, anteriorly and around periphery orange-brown, posteriorly with flange blue-green, segments 6 to 8 white, becoming progressively pink near maturity, segment 7 with a black dorso-lateral patch, anal plate brown.

Pupa (Figs 8, 9). Length 15 mm, with covering of short fine setae, longer anteriorly, indented above eyes, brown with segments 6 and 7 cream-brown, faint dorsal line brown, dark brown dorso-lateral markings anteriorly. Attached by cremaster and central girdle.

Discussion

Bindahara meeki, described by Rothschild and Jordan (1905), is one of the rarer species in the Australian region. It is fairly widely distributed from Misool and mainland Irian Jaya to eastern Papua New Guinea, yet only six specimens were known to Parsons (1998) from Papua. A further female is known from Mumeng, Morobe Province, PNG, March 1990 (CJMC).

B. meeki kolmaui is a striking new taxon and its presence on New Ireland suggests that *B. meeki* eventually will be discovered on the intervening island of New Britain. Parsons (1998) records the vertical range of *B. m. meeki* in Papua as 0-1800 m. The type series of *B. m. kolmaui* was taken at 1260 m (Fig. 13) although it may occur at lower elevations in New Ireland.

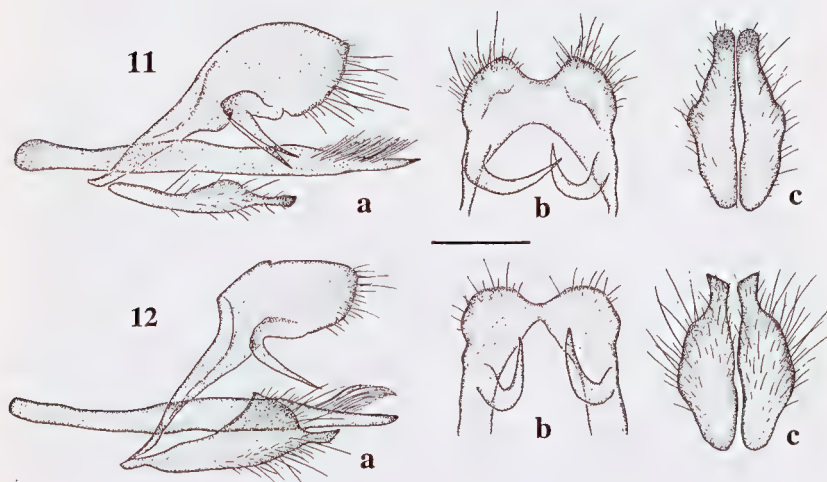
Adults of *B. m. kolmaui* may be distinguished readily from the nominate subspecies in both sexes. The male is more distinctly marked beneath than that of *B. m. meeki*., the pale striae in the tornal region of the hindwing in the latter taxon are replaced with dark, more extensive markings in the new subspecies. Above, the narrow terminal area of iridescent purple in *B. m. meeki* is replaced by a large area of similar colouring covering the majority of the forewing (Figs 5, 6). The sex mark at the costal base of the hindwing above is much larger in *B. m. kolmaui* than in the nominotypical subspecies. Females are very well marked on the underside of both wings; the vestigial bars in *B. m. meeki* are extended considerably in *B. m. kolmaui*, giving a superficial resemblance to a miniature 'five-bar' *Graphium* Scopoli (e.g. *G. nomius* (Esper), *G. aristeus* (Stoll): Papilionidae). The yellow and metallic blue markings in the hindwing are extensive and bright in *B. m. kolmaui*. In addition, the wing shape is different between females of the two subspecies. Females of the nominate taxon possess much broader and more rounded wings, the termen in *B. m. kolmaui* being comparatively straight.

The male genitalia of *B. m. meeki* and *B. m. kolmaui* (Figs 11, 12) are very distinct, suggesting that the two may not be conspecific. The sociuncus in *B. m. meeki* is considerably broader and more rounded dorsally than in *B. m. kolmaui*. In addition, the sociuncus is more flattened laterally in *B. m. meeki* and the brachium is blunt and broad. The valvae of *B. m. olmaui* are strongly flattened and unlike those of *B. m. meeki* are apically blunt (sharply pointed in *B. m. meeki*). The phallus of *B. m. kolmaui* is tapered to a sharp point apically, whilst in *B. m. meeki* it is comparatively blunt.

Adults of *B. m. kolmaui* were collected in the top of a flowering rainforest tree (probably *Acmena* sp.) some 20 m above the ground. Specimens were flying with *Deudorix woodfordi* Druce, *D. niepelti* Joicey & Talbot, *D. epijarbas* (Moore) and an undescribed species of *Deudorix* Hewitson. Several days spent in the canopy saw only very brief periods of sunshine and once the sun was obscured insect activity lessened considerably. The probable arboreal habits of *Bindahara meeki* may explain the paucity of records.



Figs 7-10. Early stages and foodplant of *B. m. kolmaui*. (7) mature larva, dorsal view; (8) pupa, dorsal view; (9) pupa, lateral view; (10) *Salacia* sp. nr *disepala*.



Figs 11-12. Male genitalia of *Bindahara meeki*. (11) *B. m. kolmaui*. (a) lateral view; (b) sociuncus, dorsal view; (c) valvae, ventral view. (12) *B. m. meeki*. (a) lateral view; (b) sociuncus, dorsal view; (c) valvae, ventral view.



Fig. 13. Type habitat of *B. m. kolmaui*, Schleinitz Mts., 1260 m, central New Ireland.

A female of *B. m. kolmaui* was observed to oviposit on a fruit of *Salacia* sp. nr *disepala* (Hippocrateaceae) which was scrambling through the canopy of a tall rainforest tree. An egg collected was subsequently reared to adult and its early stages recorded. This species is possibly the foodplant for the *Deudorix* taxa observed in the area, as *Salacia disepala* (C. T. White) is a common host for *Deudorix epijarbas* and *D. diovis* Hewitson and also for *Bindahara phocides yurgama* Couchman in northern Queensland (Cooper *et al.* 1993; pers. obs.). Although *Deudorix* larvae generally pupate in the fruit previously excavated by the larva, those of *Bindahara phocides* generally pupate within narrow chambers constructed in dead wood. The mature larvae may wander for days in search of a suitable pupation site and eventually chew a small hole and pupate within. In captivity, the mature larva of *B. m. kolmaui* wandered within its confines for six days before finally boring into some soft, partially rotten wood provided. As the mature larva neared pupation, it progressively became very pinkish in colour, noticeable also in the larvae of *B. phocides yurgama* (pers. obs.). A characteristic feature of *B. phocides* pupae is a resemblance in anterior view to a small arboreal cricket (Gryllidae), no doubt a deterrent mechanism to predators. This is also characteristic of the pupae of *B. meeki*.

Acknowledgments

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THE LIFE HISTORY OF *SABERA FULIGINOSA FULIGINOSA* (MISKIN) (LEPIDOPTERA: HESPERIIDAE) AND ADDITIONAL HOSTPLANTS FOR THE OTHER MEMBERS OF THE GENUS IN NORTHERN QUEENSLAND

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Abstract

The early stages of the white-fringed swift, *Sabera fuliginosa fuliginosa* (Miskin) are described and illustrated. New hostplants are recorded for the yellow-streaked swift, *S. dobboe autoleon* (Miskin) and the white-clubbed swift, *S. caesina albifascia* (Miskin).

Introduction

While examining foliage of the palm *Calamus moti* Bailey near El Arish, (Tully district, northern Queensland) during 1994, two hesperiine larvae were located. These were reared and proved to be *Sabera fuliginosa fuliginosa* (Miskin). Subsequently, a gravid female from Kuranda confined to a plant of *C. moti* oviposited successfully. The resultant larvae completed their life cycle on that plant.

Life history

Foodplant. *Calamus moti* Bailey (Arecaceae).

Egg (Fig. 1). Hemispherical; diameter approximately 1 mm; dome-shaped with very fine vertical ribs; cream when first deposited, some changing to deep pink in 3-4 days.

Larva. First instar: length 3.5 mm; head shiny black, smooth, with shallow longitudinal groove; prothoracic plate black; body pale straw-coloured; long pale setae on posterior segments. Second to third instars: head black; body translucent grey-green. Fourth instar: head with lower two-thirds and longitudinal groove black, remainder very light brown; body translucent grey-green. Fifth instar (Fig. 2): length 28 mm; head black with two light brown lateral areas; longitudinal groove forming a black triangle joined at the base and top by a deep brown lateral line; body translucent grey-green, dorsal midline dark green.

Pupa (Fig. 3). Length 18 mm; light cream-brown covered with white, waxy powder; attached by dark red-brown cremaster.

Discussion

As with the other Australian species in the genus, eggs of *S. f. fuliginosa* are deposited singly on the upperside of leaves of the foodplant. Larvae construct shelters using a section of the leaf margin, which they isolate at either end and fold underneath. Folding is achieved by construction of a silken hinge and tensioned silken threads. Further shelters are constructed, becoming progressively larger as the larva grows. Mature larvae then form a



Figs 1-3. Early stages of *Sabera fuliginosa fuliginosa*. (1) egg; (2) larva; (3) pupa. Scale bars (1) = 1.5 mm, (2) = 4 mm, (3) = 4.2 mm.

puparium which is detached from the foodplant and falls to the ground or often into water. In the latter situation, the tightly sealed puparium apparently maintains buoyancy. Larvae feed at night.

Only subtle morphological differences exist between the early stages of Australian species of *Sabera* Swinhoe. The early stages of species occurring outside Australia, where they are essentially restricted to mainland New Guinea (Evans 1949; Parsons 1986, 1991, 1998), are poorly known. Parsons (1998) noted that W. W. Brandt had taken larvae of *S. caesina barina* Fruhstorfer together with those of *Mimene melie* (de Nicéville) (Hesperiidae) in mainland Papua New Guinea. Parsons (1998) suggested that, based on Brandt's sketches, the foodplant was possibly *Licula* sp. or *Calamus* sp. (both Arecaceae). Parsons (1998) recorded *Cordyline terminalis* (L.) Kunth (Agavaceae) as a foodplant for *S. dobboe dobboe* (Plotz) in Papua New Guinea, based on Brandt's sketches, and one of us (CJM) has taken the early stages of the subspecies *S. d. hanova* Evans from this plant in northern New Britain and throughout New Ireland (0-700 m), Papua New Guinea.

Cordyline australis (G. Forster) Endl. (Agavaceae) is the primary hostplant of *S. dobboe autoleon* wherever the butterfly and plant are sympatric in northern Queensland. Ova and larvae were also found on *Cordyline stricta* (Kunth) Endl. in rainforest near Tully and Julatten. All immature stages have been collected on or near *Cordyline cannifolia* R. Br. throughout the Atherton Tablelands. *Cordyline terminalis* (Common and Waterhouse 1981) and *Cordyline* cultivars (Quick 1982) were the only previously recorded hostplants for this taxon.

At Kennedy (near Cardwell) and near El Arish, larvae of *S. caesina albifascia* have been taken from young *Achontophoenix alexandriae* (F.Muell.) (Arecaceae) palms growing deep within the jungle. Larvae and pre-pupae have also been collected from young *Normanbya normanbyi* (W.Hill) L. Bailey (Arecaceae) palms at Diwan and Cape Tribulation. The only previously known foodplant for this hesperiid in Australia was *Calamus carytoides* C. Martius (Arecaceae) (Wood 1985).

Sabera species are remarkable in that, upon emerging, adults remain in an upright position, with their long legs fully extended, whilst expanding their wings. They are capable of flight within minutes of eclosion, possibly minimising time spent on the forest floor or watercourse where they would be very vulnerable to predators. *Sabera* larvae can withstand temporary flooding of their habitats.

Acknowledgments

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THE GENUS *PSYCHONOTIS* TOXOPEUS IN THE SOLOMON ISLANDS, WITH DESCRIPTIONS OF FIVE NEW TAXA (LEPIDOPTERA: LYCAENIDAE)

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Abstract

Examination of *Psychonotis* Toxopeus material from Papua New Guinea and the Solomon Islands shows that two distinct taxa have previously been included under *Psychonotis kruera* (Druce). A lectotype for *P. kruera*, from Florida Island, is designated. Five new taxa are described: *P. julie* sp. nov. (San Cristobal); *P. eleanor* sp. nov. (New Georgia Group); *P. aihuru* sp. nov. (San Cristobal); *P. slithyi* sp. nov. (Malaita) and *P. slithyi borogrovesi* ssp. nov. (Ulawa). Diversity of *Psychonotis* taxa in the Solomon Islands accords closely with the distribution of other butterfly groups and with the geological history of the islands.

Introduction

The Australasian genus *Psychonotis* Toxopeus, 1930, occurs from Sulawesi in the west to New Guinea, Australia, the Solomon Islands and New Caledonia in the east. In a review of the Oriental and Australian Polyommattini, Hirowatari (1992) recognised nine species of *Psychonotis*, three of which [*P. caelius* (C & R Felder, 1860); *P. brownii* (Druce & Bethune-Baker, 1893) and *P. hebes* (Druce, 1904)] occur in New Guinea and one, *P. kruera* (Druce, 1891), extends to the Solomon Islands. Parsons (1998) also included the Solomon Islands in the distribution of *P. caelius* but no specimens from there have been seen by the present author. Parsons (1998) also referred to a male of an undescribed *Psychonotis* species from New Ireland in The Natural History Museum, London (BMNH) and included a line drawing of the valve and a colour illustration of both surfaces of the adult.

Druce (1891) described *P. kruera* from a male from Florida Island and a female from Malaita. There are few specimens of *P. kruera* in museum collections and further material, collected in 1996 and 1997, shows that the species is widespread throughout the western Solomon Islands, but that two taxa had previously been included under the name *kruera* (see *P. slithyi* sp. nov., below). It also transpired that the specimens from which *P. kruera* was described, both now in the BMNH and both bearing 'Type' labels, represented different species.

Although known *Psychonotis* species usually present no difficulties in identification, some confusion is possible. Male genitalia are distinctive. In particular, the shape of the posterior section of the valvae differs significantly between species, especially when viewed dorsally and slightly obliquely. Hirowatari (1992) illustrated the male genitalia of several New Guinea taxa,

including *P. kruera* and Parsons (1998) provided a comparison between the valves of *P. brownii* and an undescribed *Psychonotis* species from New Ireland. Further undescribed *Psychonotis* species, collected on islands of the New Georgia Group and on San Cristobal, raise the total of known species in the genus to 14. Male genitalia of *Psychonotis* species known from the New Guinea region are figured below (figs 19-26). Colour illustrations of the new taxa will appear in a forthcoming book on the butterflies of the Solomon Islands.

Systematics

Psychonotis kruera (Druce, 1891)

(Fig. 20)

Material examined. *Lectotype* ♂ [here designated], SOLOMON ISLANDS: 'Florida I., Solomon Is., Woodford / Godman-Salvin Coll. 1908-168 / Type / *Thysonotis kruera*, Type, H H Druce' (BMNH). Non-type material: Numerous specimens, including the following genitalia preparations: 7 ♂♂, Choiseul (BMNH (V) 4975, 4976, 4977, 4978, 5104, 5105, 5106); 3 ♂♂, Santa Isabel (BMNH (V) 5107, 5108, 5109); 1 ♂, Guadalcanal (BMNH (V) 5110); 1 ♂, Florida (BMNH (V) 1119) (all BMNH). PAPUA NEW GUINEA: 1 ♂, Bougainville (JT 478) (Australian National Insect Collection, Canberra).

Description. Male forewing length 14 mm; upperside dark shining blue; outer margins and hindwing inner margin narrowly bordered dark brown; forewing underside plain white, costa and outer margin with broad dark brown margins, unmarked; hindwing underside white, outer margin with broad dark brown band enclosing submarginal series of small, iridescent blue/green markings, often with reduced or vestigial series distad, especially near tornus. Genitalia (fig. 20) typical of polyommata lycaenids, but unique in that upper section of diaphragma supports sclerotised band, weakly connected to juxta and lateral processes of tegumen, thereby forming a ring surrounding, but separate from, aedeagus (Eliot 1973). Male valve with posterior 'lobe' rounded, not serrate. Female forewing upperside with pale, shining silvery blue restricted to basal area and inner margin, the costa and outer margins broadly dark brown; hindwing upperside pale silvery blue with broad dark brown outer margin; underside similar to male.

Distribution. Western Solomon Islands and Bougainville, Woodlark and Misima islands, Papua New Guinea.

Comments. The female specimen recorded by Druce (1891) becomes a paratype of *P. slithyi* sp. nov. Both *P. kruera* and *P. slithyi* are subject to individual variation and intermediate specimens may be difficult or impossible to separate using exophenotypic characters alone, although male genitalia of each species are distinctive (cf. figs 19 & 20). The abdomen of the lectotype is missing. However, the markings are clearly those of western populations (i.e. not intermediate) and the genitalia of another male from Florida island in the BMNH are identical with those from western

populations. Selection of the Florida specimen as lectotype also results in the least nomenclatural disruption, since the species is widespread throughout the western Solomon Islands and parts of New Guinea, whilst the species represented by Druce's female (*P. slithyi*) is apparently restricted to Malaita and Ulawa. So far as is known, these two closely related taxa are allopatric in distribution.

***Psychonotis slithyi* sp. nov.**

(Figs 1, 4, 10, 13, 19)

Material examined. Holotype ♂, SOLOMON ISLANDS: Malaita, Auki to Fiu river, SL-200 m, 22.x.1997, W. J. Tennent (gen. prep. BMNH (V) 5111) (BMNH). *Paratypes:* 5 ♂♂, 2 ♀♀, same data as holotype (inc. gen. prep. BMNH (V) 5112); 4 ♂, same data as holotype, 11.iv.1997 (inc. gen. preps. BMNH (V) 5113, 5114, 5115); 1 ♂, Malaita, north-east of Auki, SL-200 m, 9.iv.1997, W. J. Tennent (gen. prep. BMNH (V) 5116); 2 ♀♀, Malaita, north, above Malu'u, SL-580 m, 24.x.1997, W. J. Tennent; 1 ♀ [*paralectotype* of *P. kruera*], 'N. W. Bay, Malaita I., Solomon Is., Woodford / Godman-Salvin Coll. 1908-168 / Type / *T. kruera* f, Type, H H Druce' (all BMNH); 1 ♂, 1 ♀, Malaita, Dala, 50 m, 7-22.vi.1984, J. & M. Sedlacek (Bernice P. Bishop Museum, Honolulu).

Description. Resembles *P. kruera*; male forewing length 14 mm; upperside indistinguishable from *P. kruera*; underside marginal dark bands slightly narrower than in *P. kruera*; hindwing underside with single series of iridescent blue markings in marginal band (often with at least the suggestion of double series in area of tornus in *P. kruera*). Genitalia (fig. 19) distinctive; valve with posterior lobe deeply serrated, slightly splayed (rounded, without terminal teeth in *P. kruera*). Female similar to *P. kruera*; upperside blue slightly darker.

Distribution. Malaita.

***Psychonotis slithyi borogrovesi* ssp. nov.**

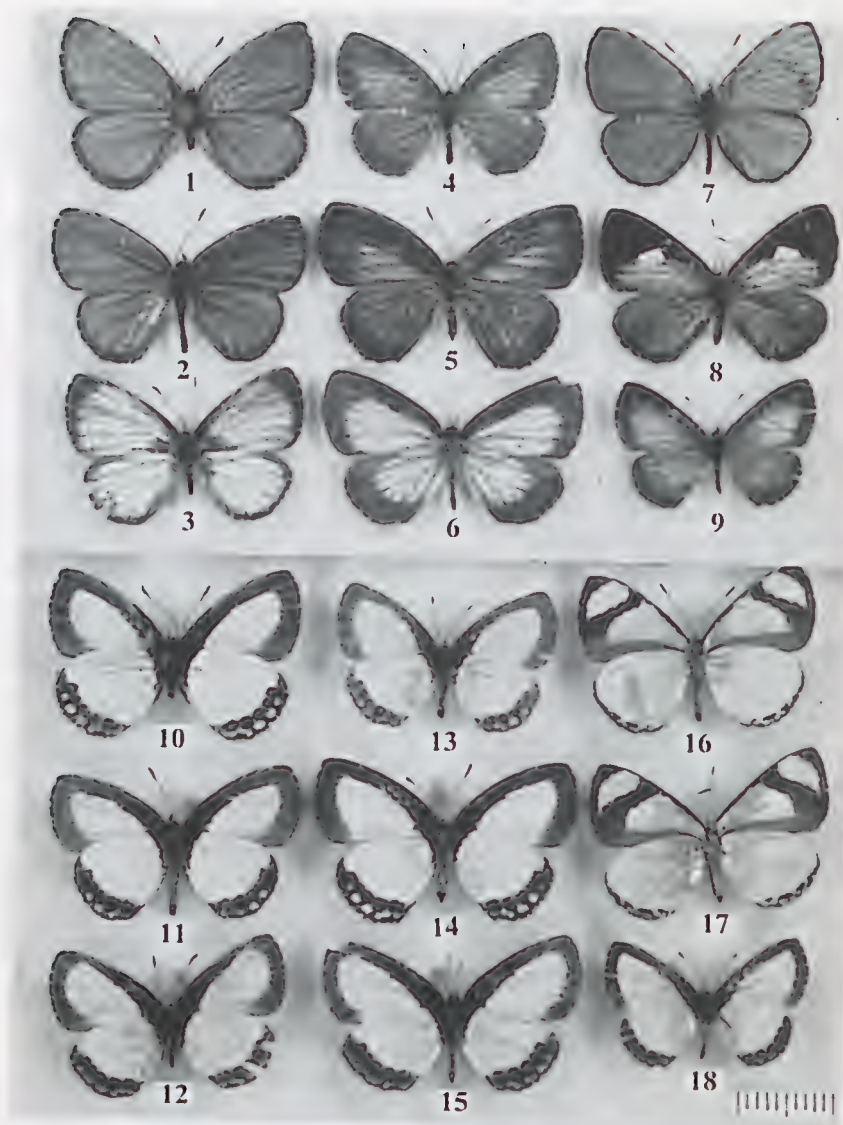
(Figs 2, 5, 11, 14)

Material examined. Holotype ♂, SOLOMON ISLANDS: Ulawa, north, Harrina village area, 40 m, 25.iii.1997, W. J. Tennent (BMNH). *Paratypes:* 9 ♂♂, 4 ♀♀, same data as holotype (inc. gen. preps. BMNH (V) 5117, 5118); 1 ♀, Ulawa, north, Kellmei and Harrina village areas, SL-40 m, 24.iii.1997 (all BMNH).

Description. Male forewing length 13 mm; indistinguishable from *P. s. lithyi*; genitalia similar to *P. s. slithyi*. Female distinctive; upperside blue dull, restricted to basal areas, leaving broad marginal border; underside marginal borders slightly broader than *P. s. slithyi*.

Distribution. Ulawa.

Comment. The island of Ulawa has a surprisingly high level of endemic butterfly taxa, considering its geographical proximity to Malaita (Tennent 1998).



Figs 1-18. *Psychonotis* species, upper and undersides. (1, 10) *P. s. slithyi* ♂ (holotype); (4, 13) ditto, ♀ (paratype); (2, 11) *P. slithyi borogrovesi* ♂ (holotype); (5, 14) ditto, ♀ (paratype); (3, 12) *P. eleanor* ♂ (holotype); (6, 15) ditto, ♀ (paratype); (7, 16) *P. julie* ♂ (holotype); (8, 17) ditto, ♀ (paratype); (9, 18) *P. waihuru* ♀ (holotype). Scale bar = 1 cm.

Psychonotis julie sp. nov.

(Figs 7, 8, 16, 17, 21)

Material examined. Holotype ♂, SOLOMON ISLANDS: San Cristobal, above Hauta, 500-700 m, 3.iv.1997, W. J. Tennent (BMNH). Paratypes: 4 ♂♂, 3 ♀♀, same data (inc. gen. prep. BMNH (V) 5119); 1 ♂, 1 ♀, same data, 1.iv.1997 (male gen. prep. BMNH (V) 5120) (all BMNH).

Description. Male forewing length 14 mm; upperside dark shining blue, with narrow black margins; underside with restricted blue-green basal suffusion; forewing underside white; apex black; inner margin broadly black; broad black postmedian transverse stripe from costa to outer margin; hindwing underside white; ternal markings consisting of marginal elongated and barely confluent black spots, extending in thin line along outer margin; iridescent blue-green markings indistinct, confined to ternal spots. Genitalia typical of *Psychonotis*; valve irregular in shape, terminating in unserrated narrow pointed lobe (fig. 21). Female upperside similar to a species of *Erysichton* Fruhstorfer, forewing upperside with apex, outer margin and tornus broadly black; prominent white discal patch; posterior section of wing bright silver-blue; hindwing upperside dusted blue, particularly near inner margin; outer margin with wide dark band; underside similar to male.

Distribution. San Cristobal.

Comment. *P. julie* is unlike any other known *Psychonotis* species.

Psychonotis eleanor sp. nov.

(Figs 3, 6, 12, 15, 22)

Material examined. Holotype ♂, SOLOMON ISLANDS: New Georgia group, Kolombangara, inland from Vanga Point, SL-400 m, 25.viii.1996, W. J. Tennent (gen. prep. BMNH (V) 5121) (BMNH). Paratypes: 1 ♀, same data; 2 ♂♂, 2 ♀♀, Kolombangara, Vanga Point, SL-40 m, 23.viii.1996, W. J. Tennent (inc. gen. prep. BMNH (V) 5122); 1 ♀, same data, 26.viii.1996; 1 ♀, same data, 27.viii.1996; 1 ♀, New Georgia, north coast, Menakasapa (Paradise), SL-20 m, 1.ix.1996, W.J. Tennent; 1 ♀, New Georgia Group, Vella Lavella, southeast corner, SL-40 m, I.J. Woods, 6.viii.1997 (all BMNH).

Description. Male forewing length 13 mm; upperside bright shining blue (dark blue in other members of the *kruera* species-group); margins brown, broader at fw apex (uniformly narrow in *P. kruera*); underside similar to *P. kruera*; hindwing underside with iridescent ternal markings in single line, prominent. Genitalia (fig. 22) superficially similar to *P. kruera* (cf. fig. 20), larger, posterior of valve with less rounded (i.e. more 'open') shape. Female upperside pale shining blue (darker in *P. kruera* and *P. slithyi*); borders brown, broad; forewing upperside with cubital vein and section of veins 2, 3 and 4 nearest cubital vein distinctly white; underside similar to male.

Distribution. New Georgia, Kolombangara, Vella Lavella and probably other islands of the New Georgia Group.

Comment. *P. kruera* has not been recorded from the New Georgia Group and is apparently replaced there by *P. eleanor*.

Psychonotis waihuru sp. nov.

(Figs 9, 18)

Material examined. Holotype ♀, SOLOMON ISLANDS: San Cristobal, above Hauta, 500-700 m, 3.iv.1997, W. J. Tennent (BMNH).

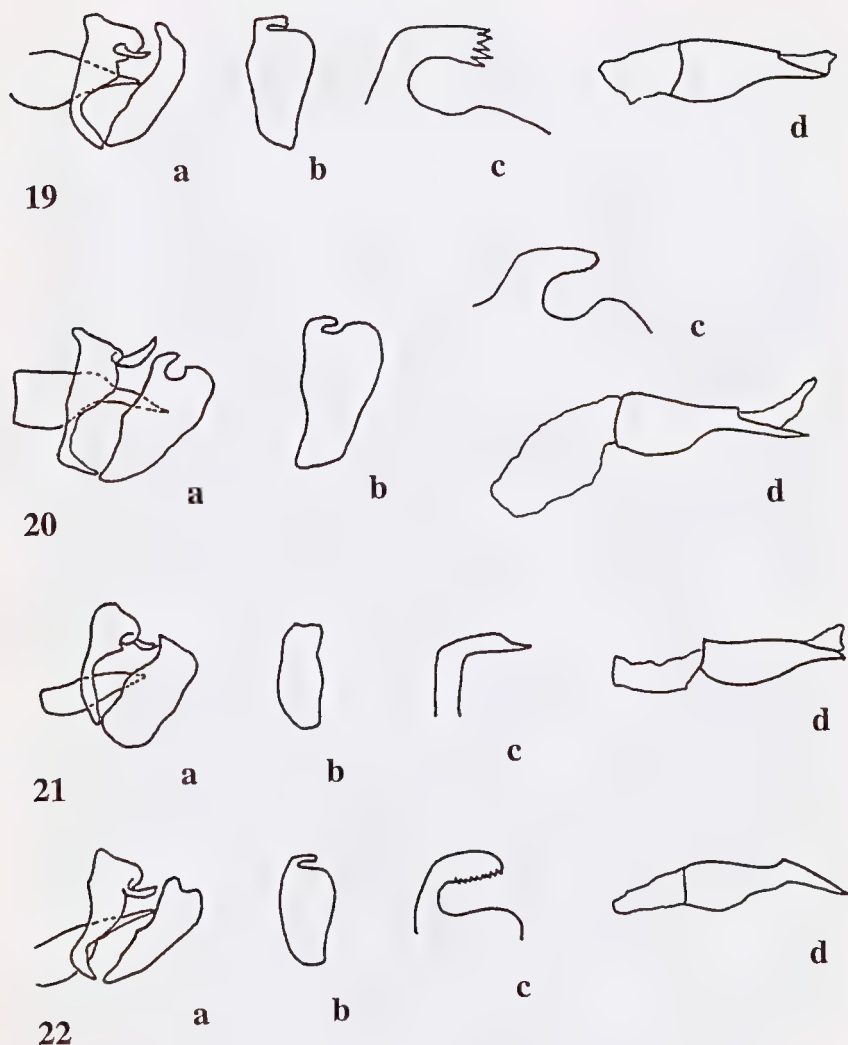
Description. Female forewing length 12 mm; similar to *P. slithyi*; upperside blue more dull; underside similar to other *kruera* species-group; forewing underside with marginal dark border narrow in comparison with *P. kruera* and *P. slithyi*, ending cleanly at tornus (becoming diffuse, slightly broader and extending slightly along the inner margin in *P. kruera* and *P. slithyi*); hindwing underside with iridescent markings small, inconspicuous. Male unknown.

Distribution. San Cristobal.

Comments. This taxon represents the first record of the *kruera* species-group from the island of San Cristobal and is named after John Waihuru, village chief at Hauta, whose interest in nature and embrace of ecotourism is a good example of a realistic alternative to the ubiquitous and destructive logging practices which pervade the western Pacific islands. San Cristobal is one of the most interesting of the large mountainous and forested Solomon islands, and supports a high percentage of endemic butterfly taxa (Tennent 1998).

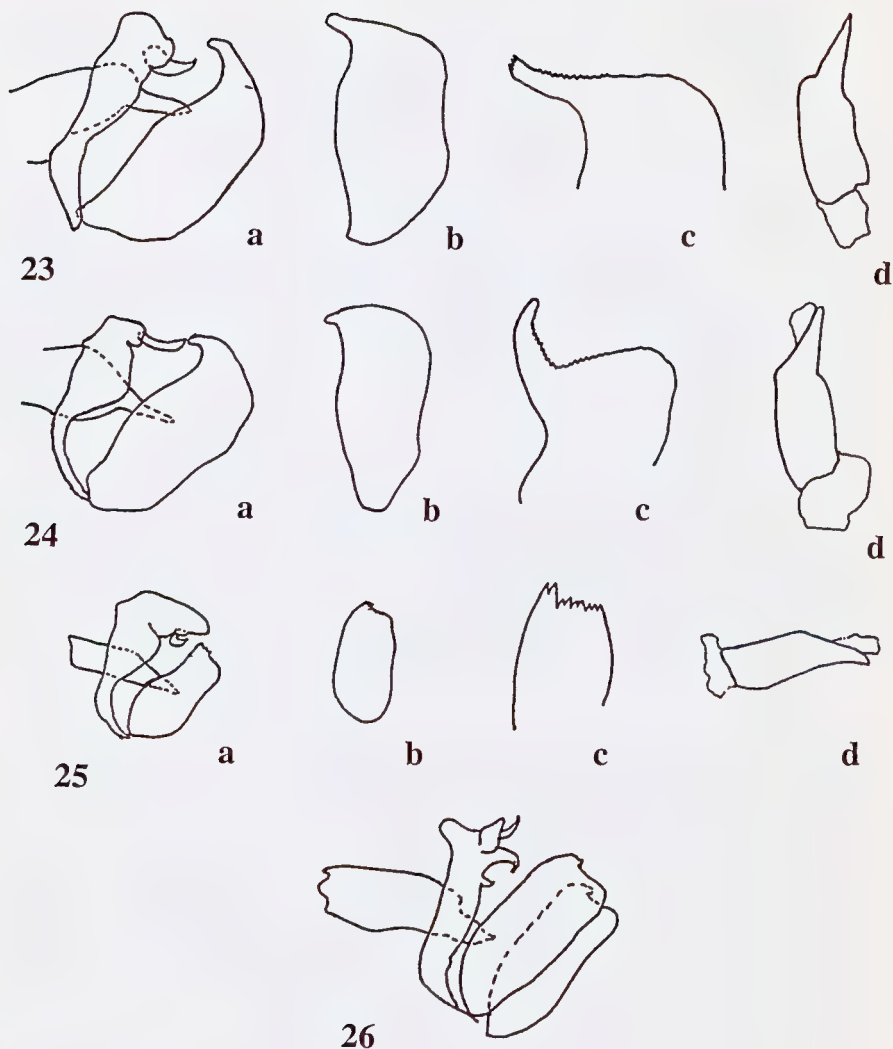
Discussion

Some minor variation in phenotype was observed in *P. kruera* from different islands although it was not possible, with the material available, to properly assess whether even further taxa are involved. On the face of it, this seems unlikely. In comparison with some of the other Solomon islands, which support a high or moderately high proportion of endemic taxa (e.g. New Georgia Group, Malaita, San Cristobal etc.), the islands of Choiseul, Santa Isabel and the Florida group have few endemic taxa (Tennent 1998). It is probable that this is a result of their role as 'stepping stones' in the spread of fauna from west (i.e. Bougainville) to east and it has even been suggested (e.g. Diamond 1983) that these islands may have formed a land-bridge as recently as 2 mya. Guadalcanal may also have been part of this 'bridge' and a bathymetric high linking these islands suggests they would certainly have been closer together during recent periods of sea level fluctuation, although much of Guadalcanal has been submerged in recent times, probably during the last 100,000 years (P. Coleman, pers. comm.). Malaita, Ulawa and San Cristobal are geologically recent (M. Petterson, pers. comm.) and support a relatively high level of endemic taxa (Tennent 1998). The known distribution of *Psychonotis* taxa in the Solomon Islands, with one taxon occurring on Choiseul, Santa Isabel, Florida, Guadalcanal and Savo



Figs 19-22. *Psychonotis* male genitalia: a, genitalia (lateral view); b, right valve (lateral view); c, posterior of valve (dorso-lateral view); d, aedeagus. (19) *P. slithyi* (Malaita); (20) *P. kruera* (Choiseul); (21) *P. julie* (San Cristobal); (22) *P. eleanor* (Kolombangara).

P. kruera) and distinct species on the New Georgia Group (*P. eleanor*), Malaita and Ulawa (*P. slithyi*) and San Cristobal (*P. julie*, *P. waihuru*)



Figs 23-26. *Psychonotis* male genitalia: a, genitalia (lateral view); b, right valve (lateral view); c, posterior of valve (dorso-lateral view); d, aedeagus. (23) *P. caelius* (New Ireland); (24) *P. hebes* (New Guinea); (25) *P. brownii* (New Britain); (26) *Psychonotis* sp. (New Ireland), genitalia.

(*P. kruera*) and distinct species on the New Georgia Group (*P. eleanor*), Malaita and Ulawa (*P. slithyi*) and San Cristobal (*P. julie*, *P. waihuru*) closely parallels the distribution of other butterfly groups as well as the islands' geological history.

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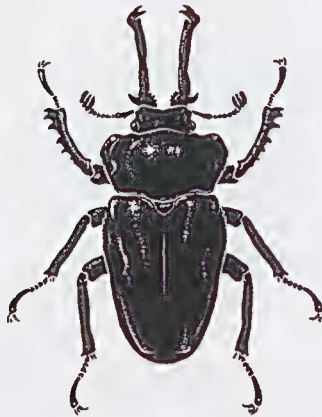
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